NERVE FIBER LAYER THICKNESS IN NORMALS AND GLAUCOMA PATIENTS

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Abstract

The Nerve Fiber Analyzer (NFA) has been up-graded with the addition of the Glaucoma Scanning System (GDx). The authors investigated the utility of the NFA GDx in glaucoma. The study material consisted of 15 eyes of 15 normal individuals and 21 eyes of 16 open-angle glaucoma patients who had visual field defects in the upper hemifield only. The results were as follows: specificity was 100% and overall sensitivity 81.0%, although the sensitivity for each individual parameter was low. In ten of 13 parameters, there were significant differences between normal subjects and glaucoma patients (*t* test, $p<0.5\%$), and even the parameters corresponding to the upper retina without visual field defects in the glaucoma patients were significantly lower than in the normal subjects. None of the normal group exhibited greater than 25 in the glaucoma number (GN) and about half the eyes with glaucoma exhibited a GN of greater than 30. It was considered that the sensitivity could be increased with a combination of some of the parameters. Nerve fiber layer defects could be detected with the NFA GDx before any appearance of visual field loss, and there was a high possibility of visual field loss if the GN was greater than 30.

Introduction

In glaucoma, optic disc changes and retinal nerve fiber layer defects can become manifest before the appearance of visual field defects.

Recently, several image analysis systems using laser scanning techniques have been developed[1-6]. One of these systems, the Nerve Fiber Analyzer (NFA), has been developed to measure the thickness of the retinal nerve fiber layer[7-14]. It was anticipated that the technology would be used for the early detection of retinal nerve fiber layer defects. The original NFA has been superseded by a new version with the addition of the Glaucoma Scanning system (GDx)[4]. Accuracy of measurement with this new system has been improved because those measurement errors depending on vascular factors have been reduced.

We then investigated the potential for early detection of retinal nerve fiber layer defects in glaucoma using the NFA GDx and the correlation of visual field defects to the NFA parameters.

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Table 1. Image quality of NFA pictures

Image check	*Pass score*	*Range of subjects*
Overall	80<	80~98
Image intensity	70<	70~100
Image vignette	70<	70~100
Even illumination	80<	70~100
Image contrast	80<	77~100
Temporal/nasal thickness	95<	95~100
Superior inferior/temporal nasal	95<	100
Amount of image used	80<	80~99
Center optic nerve	80<	83~100

NFA pictures in which image scores passed were adopted and NFA pictures which had an image score from 70 to the lower limit of the normal range in the even illumination or in the image contrast were also adopted for this study

Subjects and methods

The study sample consisted of 15 eyes of 15 normal individuals and 21 eyes of 16 open-angle glaucoma patients who had visual field defects in the upper hemifield only, as shown by both the Goldmann perimeter and the Humphrey Field Analyzer (HFA). The average age, refraction, and mean deviation (MD), and corrected pattern standard deviation (CPSD) for the HFA were 35.9 ± 17.1 years, -2.03 ± 2.15 diopters, -0.13 ± 0.98dB and 0.88 ± 0.38dB in the normal subjects and 50.2 ± 14.1 years, -3.02 ± 2.71 diopters, -7.39 ± 5.71dB and 10.49 ± 5.06dB in the glaucoma patients, respectively.

Fourteen parameters (symmetry, SY; maximum modulation, MM; ellipse modulation, EM; ellipse average, EA; average thickness, AT; superior ratio, SR; superior maximum SM; superior average, SA; superior integral, SI; superior/nasal, SN; inferior ratio, IR; inferior maximum, IM; inferior average, IA; glaucoma number, GN) derived by the GDx, were compared to the visual field defects in the upper hemifield. Specificity and sensitivity of the GDx parameters between normal subjects and glaucoma patients were determined and the correlation between the GDx parameters and the HFA global indices was also derived.

Firstly, the NFA pictures were checked by the NFA image check system. The pictures in which image quality was good and in which image scores were acceptable, were adopted for this study, except for the pictures in which 1500 pixels were not enough for a good analysis (Table 1).

Results

Specificity and sensitivity

The specificity and sensitivity were calculated from the 13 parameters of the GDx, except GN because the probability values (p values) for GN were not available in the present system. There was no eye which showed a p value of <10% for all parameters in the normal subjects. In glaucoma patients, the sensitivities for all parameters ranged from 4.8 to 47.6% and 17 of 21 eyes (81.0%) with glaucoma had at least one param-

Table 2. Sensitivity and specificity for NFA parameters

Parameters	*Sensitivity*		*Specificity*	
	%	*n*	*%*	*n*
SY	47.6	10/21	100	15/15
MM	42.9	9/21	100	15/15
EM	23.8	5/21	100	15/15
SR	33.3	7/21	100	15/15
IR	28.6	6/21	100	15/15
SN	42.9	9/21	100	15/15
EA	14.3	3/21	100	15/15
AT	14.3	3/21	100	15/15
SM	33.3	7/21	100	15/15
IM	14.3	3/21	100	15/15
SA	23.8	5/21	100	15/15
IA	23.8	5/21	100	15/15
SI	4.8	1/21	100	15/15
	81.0	17/21	100	15/15

No parameters in normal subjects showed a p value of less than 10% and the overall specificity was 100%. Seventeen of 21 eyes with glaucoma had at least one parameter with a p value of less than 10% and the overall sensitivity was 81.0%

eter with a p value of less than 10% (Table 2). Ten of 21 eyes (47.6%) with glaucoma showed at least one parameter with a p value of less than 10% in three parameters (IR, IM, IA), corresponding to the upper visual field defects. On the other hand, 15 of 21 eyes (71.4%) with glaucoma showed at least one parameter with a p value of less than 10% in five parameters (SR, SM, SA, SI, SN), corresponding to the upper retina without visual field defects.

From the above results, it was found that the specificity was 100% and the overall sensitivity 81.0%, although the sensitivity for each individual parameter was low.

Comparison of parameters between normal subjects and glaucoma patients

There was no significant difference in three parameters (SY, EA, AT) between normal subjects and glaucoma patients. For other parameters, there were significant differences between normal subjects and glaucoma patients (t test, $p<0.5\%$) and in the glaucoma patients, the parameters were significantly lower than in the normal subjects (Table 3).

There was no statistically significant difference between SR and IR in normals and glaucoma patients. However, both SR and IR were greater than 2.0 in normals and less than 2.0 in most of the glaucoma patients. There was no statistically significant difference between SM and IM in normals and glaucoma patients, and their parameters showed overlap. Neither was there a statistically significant difference between SA and IA in normals, and these parameters also exhibited overlap.

Table 3. Mean values of NFA parameters in normals and glaucoma patients

Parameter	*Normal (n=15)*	*Glaucoma (n=21)*	*p value (t test)*
SY	0.99 ± 0.10	1.00 ± 0.17	ns
MM	2.13 ± 0.59	1.14 ± 0.34	<0.0001
EM	3.26 ± 0.90	1.78 ± 0.47	<0.0001
SR	2.99 ± 0.53	1.91 ± 0.36	<0.0001
IR	3.04 ± 0.53	1.94 ± 0.42	<0.0001
SN	2.23 ± 0.32	1.70 ± 0.32	<0.0001
EA	66.33 ± 6.26	63.19 ± 9.62	ns
AT	66.33 ± 6.26	61.33 ± 9.23	ns
SM	96.07 ± 10.15	80.00 ± 14.50	0.0008
IM	97.73 ± 11.39	81.33 ± 16.69	0.0023
SA	83.53 ± 9.16	72.19 ± 12.38	0.005
IA	84.73 ± 9.69	67.81 ± 13.05	0.0002
SI	0.225 ± 0.024	0.197 ± 0.038	0.0191

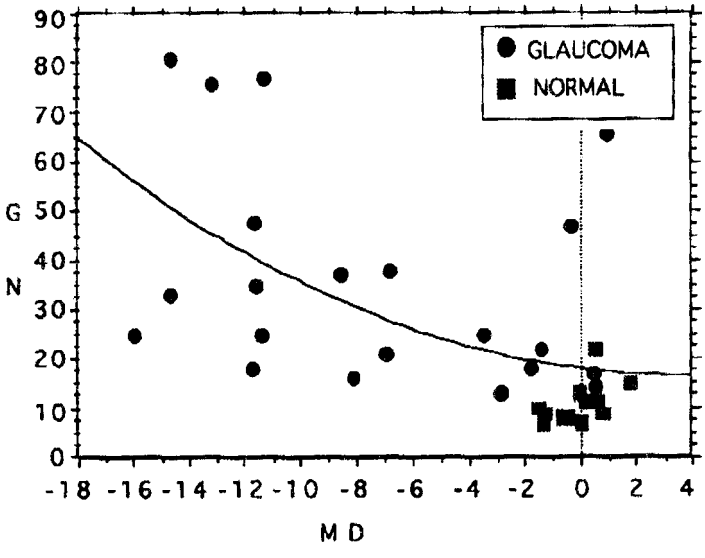

Fig. 1. Relationship between mean deviation and glaucoma numbers. Glaucoma numbers become larger as mean deviation becomes worse. There was a significant correlation in the multiple regression analysis between mean deviation and glaucoma numbers (correlation coefficient: 0.57). GN = 17.58 - 0.73 MD + 0.10 MD² (r^2 = 0.33).

Relationship between glaucoma number and visual field defects

For the relationship between GN and MD, there was a tendency for the GN to become larger as MD became worse. However, some eyes with glaucoma showed a small GN, although the MD was worse (Fig. 1). On the other hand, none of the normals exhibited a GN of more than 25 and ten of 21 eyes (47.6%) with glaucoma had a GN of more than 30 (Table 4).

Table 4. Distribution of glaucoma number

Glaucoma number	*Normal*		*Glaucoma*	
	n	*%*	*n*	*%*
GN≧30	none	0	10	47.6
30>GN≧25	none	0	3	14.3
25>GN≧20	1	6.7	2	9.5
20>GN	14	93.3	6	28.6

One of the normal subjects showed a GN of 22; the others showed a GN of less than 20. In contrast, 47.6% of glaucomatous eyes showed a GN of more than 30. Average GN for normal subjects 10.5 ± 3.9.

Discussion

In this study, the specificity of the NFA GDx was excellent at 100%. On the other hand, the sensitivity for each parameter showed low levels, and the sensitivity, which was 81.0%, was also lower than in previous reports[13,14]. The sensitivity for the three parameters corresponding to the upper visual field defects was poor at 47.6%. The sensitivity could be increased by a combination of some parameters, although the sensitivity of each individual parameter was not high.

Compared to each parameter, there was no significant difference in glaucomatous eyes between SR and IR, SM and IM, and SA and IA, although there were obvious visual field defects in the upper hemifield. Each parameter in glaucomatous eyes was significantly lower than in normal eyes, and the parameters corresponding to the upper retina without visual field defects were outside normal limits. These latter results indicated that the nerve fiber layer defects in the upper retina were detected with NFA GDx before any appearance of visual field defects.

GN was developed as a parameter in order to determine the degree of glaucoma. However, the meaning of GN is still not clear. In this study, none of the normals exhibited a GN of more than 25, while about half the eyes with glaucoma had a GN of more than 30. It was considered that there was a high possibility of visual field loss if the GN was more than 30. However, the degree of visual field loss could not be predicted by GN alone; some eyes with glaucoma showed small GNs and large negative MDs.

Earlier diagnosis of glaucoma might be possible using the NFA GDx.

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